

## PRESERVING THE LAST GREAT PLACE: NOAA'S ECOSYSTEM APPROACH TO STUDYING THE ANTARCTIC

by Sarah M. Shoffler



April 12, 2006 — On March 19, 2006, the [NOAA U.S. Antarctic Marine Living Resources research program](#) completed its 18th annual field season in Antarctica. "Antarctica is really one of the last great places on Earth," says [Rennie Holt](#), director of the AMLR program at the [Southwest Fisheries Science Center](#) in La Jolla, Calif. The Antarctic is the coldest, driest, windiest, highest continent that is still pristine, yet highly vulnerable to human activities. The AMLR program is part of the NOAA Fisheries Southwest Fisheries Science Center, which is charged with collecting the scientific information necessary to protect and manage living marine

resources in the Pacific and the Antarctic. **(Click NOAA image for larger view of an adult chinstrap penguin at Cape Shirreff, Livingston Island. Click [here](#) for high resolution version, which is a large file. Please credit "NOAA/Mike Goebel.")**

### The Mandate

NOAA's Antarctic program is not science for the sake of science. The program fulfills the responsibility the United States assumed by signing the [Convention of the Conservation of Antarctic Marine Living Resources](#) in 1982, part of the Antarctic Treaty system. Congress established AMLR with the [Antarctic Marine Living Resources Convention Act of 1984](#). "We are charged with providing the scientific information needed to conserve and manage the marine living resources in the oceans surrounding Antarctica. And CCAMLR requires that we use an [ecosystem approach](#)," says Holt.

This means that researchers study not only the targeted species of fisheries, such as krill, but also the predators, such as fur seals and chinstrap penguins, that depend on them. One of NOAA's strategic objectives is to implement ecosystem approaches to management in its many domestic and international responsibilities: the experience of CCAMLR provides an excellent example of ecosystem approaches in action. **(Click NOAA image for larger view of Antarctic krill. Click [here](#) for high resolution version, which is a large file. Please credit "NOAA/Jessica Lipsky.")**



The AMLR program is one of the few examples of, and sets NOAA-wide standards for,

ecosystem-based research, which integrates physical, biological and anthropogenic influences on living marine resources.

The long-term objective of the AMLR program is to describe the relationships between Antarctic krill (*Euphausia superba*) and its predators, along with key environmental variables so CCAMLR can understand the impact of and thus, manage the krill fishery wisely. Krill are a key component in the Antarctic food chain, and human impacts on them could have disastrous consequences for their predators. To do this, AMLR conducts top-down and bottom-up research using an ecosystem approach. **(Click NOAA image for larger view of Cape Shireff field camp and an Antarctic fur seals in foreground. Click [here](#) for high resolution version, which is a large file. Please credit "NOAA/Mike Goebel.")**

"Our studies evaluate predator responses to changes in the availability of their food, and how the distributions of finfish and krill [the prey] are affected by both physical and biological aspects of their habitat," Holt explains. Holt's team of researchers contribute their data, along with other countries in CCAMLR (e.g. Britain and Australia), to the management arm of CCAMLR. Once scientists collect enough data to elucidate relationships between predators, their food and environmental changes, CCAMLR will have the capability to manage the living resources in the Southern Ocean using an ecosystem approach. They will be able to ensure the sustained harvesting of krill, fish and crabs, balancing it with healthy predator populations, thus ensuring the health of the Antarctic.

To conduct their studies, the AMLR research team heads south beginning in October and work through the Antarctic summer, to collect predator data in the South Shetland Islands on fur seal, elephant seal and three penguin species. Concurrently, they document prey — krill, finfish and crab — abundance and distribution along with oceanographic, environmental and primary productivity data onboard the *R/V Yuzhmorgeologiya*, a chartered Russian research vessel. The program requires extended field operations, both at sea and on the ice, at a series of small camps.





## Top-Down Research

Among the AMLR researchers who study land predators, animals such as fur seals and chinstrap penguins who spend part of their life cycle on land, is Mike Goebel, a NOAA wildlife biologist. He studies fur seals at Cape Shirreff, Livingston Island in an effort to elucidate the effects of krill fishing and ecosystem variability on these top-level predators; basically they conduct "ocean observations" as seen "through the eyes of the animals." He explains that how well upper-trophic level predators are doing is a good indicator of the health of an ecosystem in general. "Predators integrate what goes on below them in the food chain. You can look at these predators and see signals of changes." **(Click NOAA image for larger view of Mike Goebel and Birgitte McDonald getting a Southern elephant seal ready for measurement, tagging, etc. Click [here](#) for high resolution version, which is a large file. Please credit "NOAA/Scott Seganti.")**



Each year, Goebel and his colleagues conduct the same protocols on these predators, yielding more and more data every year. For example, the AMLR team has tagged a population of adult female fur seals. They monitor this population to see who returns after the winter during which the animals may travel as far north as the Patagonia Shelf, or even out of the Antarctic. The AMLR team measures the proportion of that population that returns and who returns pregnant and gives birth. Collecting these two pieces of information allows the scientists to get an idea of the health of the ecosystem in general and is cost-effective to boot. **(Click NOAA image for larger view of Steve Sessions (background), Stephanie Wilson, Kyla Zaret, Darci Lombard, the zooplankton team onboard the *R/V Yuzhmorgeologiya*, sorting, counting, identifying Antarctic zooplankton. Click [here](#) for high resolution version, which is a large file. Please credit "NOAA/Ryan Driscoll.")**



Explains Goebel, "We have easy access to these colonial breeders, and have many known individuals that predictably return to the same location year after year." Therefore, monitoring their health, reproductive success and population status is much less cost intensive than for other top predators, plus they are a good indicator of what is going on farther down in the food chain.

In another study, the AMLR team, in collaboration with Chilean colleagues, puts 500 tags on fur seal pups, and looks at their survival rates from year to year. The animals don't always return in their first year, so it takes several years to know which animals survived their first winter. From these data, AMLR researchers can get an idea of what's occurring in the animals' environment over a large temporal and spatial scale. And what they've learned is that the juveniles are the weakest link in the Livingston Island population. "For instance, I know that the fur seal pups born in 1999 had good survival after they were weaned. We know that the following year class (2000) had really poor survival because we've seen very few tagged animals return. We have only one year of tag return data for the 2004 year-class so I can not say definitively, but from just the first year of data, I would wager that they did not have good survival after weaning," said Goebel. **(Click NOAA image for larger view of Mike Goebel holding recently tagged**



**Antarctic fur seal pup. Click [here](#) for high resolution version, which is a large file. Please credit "NOAA/Brian Parker."**)

### Bottom-Up Research

During the same time period, scientists conduct region-wide surveys of krill and oceanographic conditions near the Shetland Islands onboard the *R/V Yuzhmorgeologiya*. The goal of the ocean-based research is to monitor and understand fluctuations in krill populations over time in relation to fishery catches, and determine whether those catches affect fur seal or penguin reproductive success. In other words, is the fishery directly competing with land-based predators at any given time? And if so, to what extent? Christian Reiss, fishery biologist for AMLR explains, "The long-term dynamics and fluctuations can be larger than the fishery catch in a year or over a month. So we're trying to tease out the effect of the fishery in a given month, or even within a year, from fluctuations in the population size of krill,



or local abundance of krill as it's affected by ocean currents." **(Click NOAA image for larger view of the *R/V Yuzhmorgeologiya*, a Russian research vessel. Click [here](#) for high resolution version, which is a large file. Please credit "NOAA/Steve Sessions.")**



AMLR uses its annual trawl surveys to estimate the abundance and the size-composition of krill in the area of the South Shetland Islands. Reiss explains, "It is the size-composition information we collect that better indicates the reproductive success of krill." This is because local abundance might change, due to local currents, but the proportion of krill of different sizes indicates the proportion of the population that are new recruits. And knowing how the krill are doing is important to understanding how much the krill-dependent predators have to eat. **(Click NOAA image for larger view of Christian Reiss, Marcel Van Den Berg (left) and Anthony Cossio (background) working up data in Yuz computer room. Click [here](#) for high resolution version, which is a large file. Please credit "NOAA/Russell Haner.")**



This underlines the importance of a long-term continuous time series of data. Reiss explains, "If the environment itself is not constant from year to year, and the ecosystem experiences long-term changes. We prefer to collect long time data series to relate changes across many factors because the system is so complex."

### U.S. Leadership in CCAMLR

In 2000, AMLR participated in a four-country, four-ship one-month survey of CCAMLR's subareas (South Shetland, S. Orkney, S. Georgia and S. Sandwich Islands) to determine a krill quota of 4 million tonnes. Although the entire CCAMLR krill harvest is taken in these subareas and is around 100,000 tonnes, explains Holt, "the krill catch historically has been conducted within 100 km of predator reproductive areas. It is the local fishing pressure near the predators that has motivated CCAMLR to work towards setting total allowable catch, or TAC, individually for each of these smaller areas." **(Click NOAA image for larger view of Gentoo penguin with two chicks. Click [here](#) for high resolution version, which is a large file. Please credit "NOAA/Anthony Cossio.")**



CCAMLR meets each October in Australia and this year the member nations will collaborate to determine local TACs. They've agreed to use a model developed by Southwest Fisheries Science Center scientists and populated with U.S. AMLR data that looks at fishing effects on predators and prey. From this, they'll develop a set of options for different catch levels in local areas. "We're just now getting enough data that it is useful to look at as a time-series," explains Holt. "The key is that we have enough to illustrate what's happening and why. The real value of a time-series is in being able to use that information and predict what will happen given a set of options."

"Taking an ecosystem approach to management is perhaps the best way to address conservation and commercial fishing issues," says Reiss. "We are just starting that process within the continental United States and the 200 mile limit of the exclusive economic zone. But our AMLR program started that process 20 years ago. So we have a jump start. In many ways, our program is a model to use in designing and implementing an ecosystem approach." **(Click NOAA image for larger view of Russell Haner, Birgitte McDonald, Rachael Orben and Elaine Leung beside a Southern elephant seal with satellite tracking instrument attached. Click [here](#) for high resolution version, which is a large file. Please credit "NOAA/Mike Goebel.")**



**(Click [here](#) for high resolution version, which is a large file. Please credit "NOAA/Mike Goebel.")**

Although Antarctica is an area lacking permanent human habitation, it supports a wealth of wildlife. Human activities (including the impacts of fisheries) and changing climate regimes mean that even in this vastest of lands, we can not take Antarctic's bounty for granted. AMLR and CCAMLR offer a new way forward in managing complex ocean systems using an ecosystem approach. NOAA is key to further developing this management approach and providing critical information linking changes in the Earth's climate to the productivity of the Antarctic ecosystem.

#### **Relevant Web Sites**

[NOAA Antarctic Marine Living Resources Web page](#)

[NOAA Southwest Fisheries Science Center](#)

[Antarctic Marine Living Resources Convention Act of 1984](#)

[International Polar Year](#)

[National Science Foundation](#)

[Antarctic Conservation Act of 1978](#)

[Convention on the Conservation of Antarctic Marine Living Resources](#)

[Effects of Sea-ice Extent and Krill or Salp Dominance on the Antarctic Foodweb](#) (Letter to Nature. *NATURE*. Vol. 387. June 26, 1997. pages 897-900.)

[Setting a Precautionary Catch Limit for Antarctic Krill](#) (*Oceanography*. Vol. 15. No. 3. 2002. pages 26-33.)

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